

**CONTENTS**

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>TITLE</b>	i
	<b>DECLARATION</b>	ii
	<b>DEDICATION</b>	iii
	<b>ACKNOWLEDGEMENT</b>	iv
	<b>ABSTRACT</b>	v
	<b>ABSTRAK</b>	vi
	<b>CONTENTS</b>	vii
	<b>LIST OF TABLES</b>	x
	<b>LIST OF FIGURES</b>	xi
	<b>LIST OF ABBREVIATIONS</b>	xiv
<b>CHAPTER 1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Introduction	1
	1.2 Statement of Problem	2
	1.3 Objective of the Study	3
	1.4 Scope of Study	3
	1.5 Significant of the Study	4
<b>CHAPTER 2</b>	<b>LITERATURE REVIEW</b>	<b>5</b>
	2.1 Introduction	5

2.2	Types of Precast Frame	6
2.3	Precast Concrete Connections	10
2.3.1	Simple Beam-to-Column Connection in Precast Concrete Structures	11
2.3.1.1	Open Column Connection – Beam Support on Corbel	11
2.3.1.2	Hidden Connections at Column Face	13
2.3.1.2.1	Steel Billet	13
2.3.1.2.2	Cleat Connector	15
2.3.1.2.3	Welded Plate Connector	16
2.3.1.2.4	Sliding Plate	17
2.4	Connection Design Criteria	19
2.5	Column Insert Design	20
2.6	Load-Displacement Relationships	22
2.7	Moment-Rotation Relationships	23
<b>CHAPTER 3</b>	<b>RESEARCH METHODOLOGY</b>	<b>25</b>
3.1	Introduction	25
3.2	Research Design and Procedure	25
3.3	Materials Used to Form the Specimens	36
3.3.1	Concrete	36
3.3.1.1	Cube Test	37
3.3.1.2	Slump Test	38
3.3.2	Reinforcement	38
3.3.3	Formwork	39
3.3.4	Steel Connectors	41
3.4	Experimental Setup and Procedures	41
<b>CHAPTER 4</b>	<b>RESULTS AND ANALYSIS</b>	<b>47</b>
4.1	Introduction	47

4.1.1	Moment-Rotation Calculation Method	48
4.2	Specimen 1 (S-R)	49
4.2.1	Load-Displacement Relationship	49
4.2.2	Moment-Rotation Relationship	50
4.2.3	Failure Mechanisms	51
4.3	Specimen 2 (S-P1)	53
4.3.1	Load-Displacement Relationship	53
4.3.2	Moment-Rotation Relationship	54
4.3.3	Failure Mechanisms	55
4.4	Specimen 3 (S-P2)	57
4.4.1	Load-Displacement Relationship	57
4.4.2	Moment-Rotation Relationship	58
4.4.3	Failure Mechanisms	58
<b>CHAPTER 5</b>	<b>DISCUSSIONS</b>	<b>60</b>
5.1	Introduction	60
5.2	Load-Displacement Relationship	60
5.3	Moment-Rotation Relationship	64
5.4	Failure Mode	66
<b>CHAPTER 6</b>	<b>CONCLUSIONS</b>	<b>69</b>
6.1	Introduction	69
6.2	Conclusion	70
6.3	Suggestion for Future Study	71
	<b>REFERENCES</b>	<b>72</b>
	<b>APPENDIX</b>	<b>74</b>

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
5.1	Comparison of deflection between rigid and precast specimen	62
5.2	Summary of failure for each specimen	66

## LIST OF FIGURES

<b>FIGURE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
2.1 (a)	The frame wall	7
2.1 (b)	The frame wall	7
2.2 (a)	The portal frame	8
2.2 (b)	The portal frame	8
2.3 (a)	The skeletal structure	9
2.3 (b)	The skeletal structure	9
2.4 (a)	Typical figure of corbels and nibs connection	12
2.4 (b)	Beam-to-column connection using corbels and nibs	12
2.5 (a)	Beam-to-column connection using steel section	14
2.5 (b)	Beam-to-column connection using steel section	14
2.5 (c)	Beam-to-column connection using steel section	14
2.6 (a)	Beam-to-column connection with cleat connector	15
2.6 (b)	Beam-to-column connection with cleat connector	16
2.7 (a)	Beam-to-column connection using solid section with welded plate connector	17
2.7 (b)	Beam-to-column connection using solid section with welded plate connector	17
2.8 (a)	Beam-to-column connection with sliding plate	18
2.8 (b)	Beam-to-column connection with sliding plate	18
2.9	Basic principle for design of column inserts	21
2.10	Typical load-displacement curve	23
2.11	Typical moment-rotation curve	24
3.1	Elevation view of monolithic specimen (S-R)	27
3.2	Front view of monolithic specimen (S-R)	27
3.3	Plan view of monolithic specimen (S-R)	28
3.4	Perspective view of monolithic specimen (S-R)	28

3.5	Photo of monolithic specimen (S-R)	29
3.6	Photo of reinforcement connection for monolithic specimen (S-R)	29
3.7	Elevation view of precast specimen (S-P1)	30
3.8	Front view of precast specimen (S-P1)	30
3.9	Plan view of precast specimen (S-P1)	31
3.10	Perspective view of precast specimen (S-P1)	31
3.11	Photo of preparation for precast specimen (S-P1)	32
3.12	Photo of column insert for precast specimen (S-P1)	32
3.13	Elevation view of precast specimen (S-P2)	33
3.14	Front view of precast specimen (S-P2)	33
3.15	Plan view of precast specimen (S-P2)	34
3.16	Perspective view of precast specimen (S-P2)	34
3.17	Photo of preparation for precast specimen (S-P2)	35
3.18	Photo of column insert for precast specimen (S-P2)	35
3.19	Photo of concreting work	36
3.20	Photo of completed specimen	37
3.21	Photo of cube test sample	37
3.22	Photo of compression test	38
3.23	Photo of reinforcement for all specimen	39
3.24	Photo of reinforcement preparation	39
3.25	Photo of formwork preparation for monolithic specimen	40
3.26	Photo of completed formwork	40
3.27	Photo of steel connectors	41
3.28	Typical experimental setup	42
3.29	Photo of experimental setup for monolithic specimen (S-R)	43
3.30	Photo of experimental setup for precast specimen (S-P1)	43
3.31	Photo of experimental setup for precast specimen (S-P2)	44

3.32	Photo of load cell	44
3.33	Photo of LVDT	45
3.34	Photo of inclinometer	45
3.35	Photo of inclinometer	46
3.36	Photo of data logger	46
4.1	Location of testing equipment	48
4.2	Moment-rotation calculation method	49
4.3	Load-displacement curve of S-R	50
4.4	Moment-rotation curves of S-R	51
4.5	Failure mode of specimen S-R (right side)	52
4.6	Failure mode of specimen S-R (left side)	52
4.7	Failure mode of specimen S-R (top of beam)	53
4.8	Load-displacement curve of S-P1	54
4.9	Moment-rotation curves of S-P1	55
4.10	Failure mode of S-P1	56
4.11	Failure mode of S-P1 (splitting crack)	56
4.12	Load-displacement curves of S-P2	57
4.13	Moment-rotation curves of S-P2	58
4.14	Failure mode of S-P2 (right side)	59
4.15	Failure mode of S-P2 (left side)	60
5.1	Load-displacement relationship	63
5.2	Moment-rotation curve	65
5.3	Failure mechanism at connection part of precast beam	68
6.1	Providing horizontal U-bars at bolt sleeve in precast beam	71

## LIST OF ABBREVIATIONS

%	- percentage
°	- degree
$A_s$	- area of tension steel reinforcement
$a_v$	- level arm distance to shear force
$b$	- breadth of section
$d$	- effective depth of section to tension steel
$f_{cu}$	- characteristic compressive strength of concrete
$f_y$	- ultimate yield stress of steel
$h$	- depth of section
kg	- kilograms
kN	- kilo Newton
kNm	- kilo Newton meter
m	- meter
M	- bending moment
m <sup>3</sup>	- meter cubes
milirad	- miliradian
mm	- millimeter
N/mm <sup>2</sup>	- Newton per millimeter square
$N_u$	- horizontal force
$\phi$	- rotation
rad	- radian
V	-shear force
$v$	- shear stress
$v_c$	- design concrete shear stress
$V_u$	- gravity load



$\Delta$	- deflection
$\Delta u$	- ultimate deflection
$\Delta y$	- initial yield deflection
$\mu\text{m}$	- micrometer
$\phi u$	- ultimate rotation
$\phi y$	- initial yield rotation
$\pi$	- “pi”, mathematical constant equal to 3.141592654
$\Phi$	- diameter